THE TELEGRAPHIC JOURNAL.

VOL. III.—No. 58.

UNDERGROUND WIRES.

THERE are few periods that are so distinctly marked in the annals of telegraphy in England as the famous year 1866, when all the lines radiating away from the Metropolis were swept away in a fearful snow storm in January of that year. A fall of snow, a thaw, another fall, a frost and a severe gale, rapidly succeeding each other, snapped off our overladen poles, and broke our ice-laden wires into such terrible disorder, that one old soldier-lineman pronounced it, with tears in his eyes, to be "worse than the battle of Waterloo." It was felt at the time that the only panacea for such destruction was to be found in underground wires, but the experience in gutta-percha covered wires placed underground was sadly against their further employment on a large scale. The Electric Telegraph Company had in the year 1853 laid down eight gutta-percha covered wires between London, Manchester, and Liverpool, along the London and North Western Railway, but after a few years' experience they had to take them up again. The Magnetic Company, about the same period, laid down similar wires along the Lancashire and Yorkshire Railway, between Liverpool and Manchester, and along the high-roads between Manchester, Birmingham, and London, and northwards of Manchester, with similar results. The Submarine Company laid similar wires with similar results between London and Dover. Hence telegraph engineers became chary of touching underground wires. Yet underground wires were employed with success through our chief cities, and the fact gradually became patent that the early failures were solely due to want of experience. There was nothing defective in the gutta-percha itself. Left in water it appeared indestructible, but exposed to air and light it decayed. Maintained apart from the oxygen of the air its durability was unquestionable. Saturated with coal-tar it perished. Exposed to the sun the conductor lost its concentricity, and its insulation was lost. Testing was unknown, except in a very rough-and-ready way, and the wires were drawn into the pipes in the most ruthless and cruel manner. Horses were used for this purpose in the streets of London, and the order was—"Pull them in, never mind how, but pull them in." Thus the wires became full of injuries and faults. Jointing was scarcely known. Dirty, greasy hands were satisfied in making a joint that externally pleased the eye, but the searching test of the current was not thought of. Even the manufacture was in its infancy. Now, thanks to the improvements of Truman, Chatterton, and others, the manufacture is well-nigh perfect. Joints are scientifically made, tests are of the most delicate and penetrating character, the wires are drawn in with tender and nurselike care, the wire itself is carefully prepared, protected, and never exposed, its enemies—such as coal-tar—are known and carefully eschewed, and there is every indication that underground wires can be made as indestructible as submarine cables. Confidence is being restored, and the system is being gradually extended. In 1871 Mr. Culley laid down fourteen wires between Manchester and Liverpool. There are over 3,000 miles of underground wire in London.

There are many reasons why underground wires should be more extensively employed. Nothing can be more unsightly than the network of overhouse wires that destroy the skyline of our streets. Underground wires are not only sightless, but, away as they are from all atmospheric disturbances, they are free from accident, and are almost entirely free from interruption. Their repairs are consequently few and far between, and their cost of maintenance is therefore comparatively small. Moreover, when an accident does occur its locality is so accurately measured by the perfect system of testing now in vogue, that its repair is a matter of ease and rapidity.

But the system is costly, and when underground wires are employed in long lengths, the retarding influence of induction tends to reduce the speed of working; but when it is remembered that the Atlantic cables are now worked with a speed greater than that attained in the first underground wires between London and Liverpool, we may easily surmise that any retardation on our long underground lines will readily succumb to the theoretic knowledge and practical skill of the present day. Indeed the equable condition of underground wires is remarkably favourable to duplex and Wheatstone's automatic system of working. The capacity of such wires so worked is practically equal to that of overground wires of similar lengths.

The decay of overground wires in some localities, such as the smoky approaches to our manufacturing towns, is so rapid that underground wires in such places in the long run become absolutely cheaper. This is felt so much in London that our underground system is being rapidly pushed into the country. Thus towards the west it extends as far as Hounslow; in the south as far as New Cross; in the north beyond Highgate; and

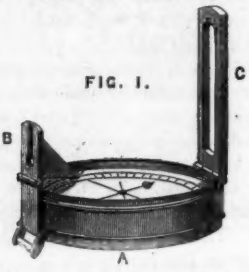
doubtless as our system increases we shall hear of underground trunk lines as far as Birmingham or Bristol.

ON TELEGRAPH CONSTRUCTION.

By JOHN GAVEY, Assoc. Soc. T. E.

(Continued from page 141.)

FIG. 1.



The prismatic compass is, perhaps, the most simple instrument for measuring angles roughly. It is illustrated in the attached sketch, figure 1. A is an ordinary compass box, fitted with a sight vane, C, across which a fine wire is extended vertically. The plate B is provided with a narrow slit, through which the sight is directed, and is fitted with a prism, by which the degrees on the compass card are seen in a line with the wire on the sight vane, the instrument being directed first to one object, so that the wire, when seen through the slit, covers it; the observed reading on the compass scale is recorded, and the difference between that and the reading, when the instrument is turned to the other object, gives the angle which they form with the position of the observer.

Actual measurements of angles are, however, but rarely taken in ordinary telegraph surveying. The angle is generally judged by the eye. It can easily be measured with the chain, thus: giving three positions, A B C, fig 2, it is desired to ascertain the angle.

FIG. 2.

The distance from A to B having been measured, a staff or rod is placed at D, so that A D C form a straight line, and the angle A D B a right angle. Dividing B D by A B or the fraction $\frac{B D}{A B}$ is the cosine of the angle A B D. A reference to an ordinary table of Sines will give the value of this in degrees, which is half A B C, when A B is equal to B C. When they are not equal, the angle C B D must be found in a like manner, and the sum of the two gives the angle A B C. If the lines A D and D B be measured, the fraction $\frac{A D}{D B}$ represents the tangent of A B D, the actual value being obtained as in the former case.

Levels are judged by the eye, or by the simple use of the ranging or offset staves.

A description of the more complicated surveys needed in an uninhabited country, by means of the level and theodolite, is beyond the scope of the present articles. Those who seek further information on this subject, are directed to the small work by T. Baker, C.E., one of those excellent little rudimentary manuals published in Weale's series.

The officer who surveys should be accompanied by three or four men. It is false economy to stint labour in a survey, for it involves delay, wastes the surveyor's time, and depreciates the ultimate value of the work. He should provide himself, in addition to the foregoing instruments, with some, or all of the following materials:—A spade, a light pointed bar, a can of white paint, and a brush; and if plugs are used, a light hand-cart and small sledge hammer. The spade, paint, and plugs are intended to mark the position chosen for each pole, this being done sometimes by removing a spadefull of soil or "spit," as it is termed—a convenient method with turf; sometimes by a paint-mark—generally a /|\ on the nearest fence; and sometimes by driving in a plug exactly at the point where each pole must stand. These plugs consist of any description of timber that is available, cut about 18 inches long by 2 inches square, and pointed at one end. Old poles or any waste wood will serve for these.

We prefer the paint and the plug combined, for the first catches the eye very readily if the latter is hidden by vegetation, and this indicates to the workmen, without doubt, the exact point where the holes must be dug. The paint-marks, too, are very permanent, standing out clearly for a long period; but both the others are in some localities very evanescent, the "spit" being filled up or grown over, and the plugs being pulled up by children for amusement.

Everything being prepared, and the position for the terminal pole being fixed upon, the men are disposed in readiness for the start. If it be a straight length of road that presents itself, a guiding or ranging rod is erected at its furthest extremity, and the measurement is commenced from the point where the terminal pole is to be erected. When the men have measured the distance that has been fixed upon as the span for straight lengths, an offset rod is held vertically at number two pole, and a man standing at the first pole, with another rod, ranges the second one, until it is in a straight line with the distant signal previously erected. The distance of the pole from the hedge, wall, fence, or other convenient boundary, is then measured at right angles to the line and entered in the offset column of the survey book, together with the other particulars detailed below.

The position of the pole is marked by either of the means above mentioned, that may have been selected, and the men start again, measuring towards number three pole. Number one man moves to number two pole, gives the range to number three, the particulars are again entered, and so on. If this is carefully done, the poles when erected will be found to be in a straight line, so that standing behind one, and looking in the line of the wires, all the others are invisible.

If the road curves, the same process is repeated, the spans being, however, shortened according to circumstances.

The surveyor judges the acuteness of the angle by estimating the length of the perpendicular A D in fig. 2, and in accordance with this he varies the span, provides for larger or heavier timber, or deals with the estimated strain, as circumstances direct.

The survey-book should contain all the information necessary for the subsequent operations. It is not generally customary in England to prepare a plan of the line.

The necessary particulars are simply entered in columns ruled for the purpose. The following is an example of one form.

Consecutive No of Pole.	Span in yards.	Length of pole in feet	Dimensions.	Offset in feet.	Stay.	Strut.	Remarks, including way leave particulars.

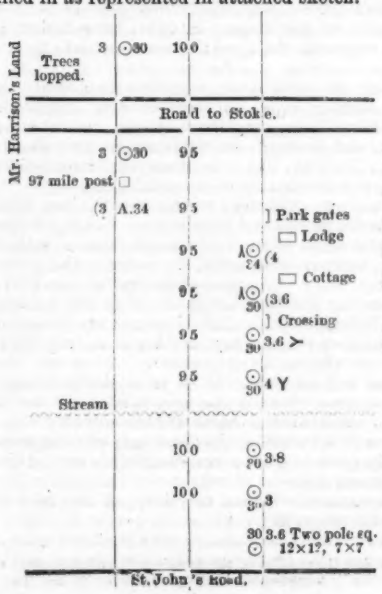
Most of the headings themselves explain their utility. The column for "dimensions" need only be filled in where specially heavy or square timber is needed. The "remarks" should include the name and address of owner and tenant, in all cases where poles or their supports, have to be fixed on private property. All the consents for such are to be obtained before the work on any given section is commenced.

Distinguishing objects, such as mile posts, crossings, &c., should be entered in the "remarks." They form a convenient check against possible error arising from missing an entry, either in laying out stores, or in subsequenty erecting poles.

The survey book sketched out might, however, be readily replaced by a plan, which by the use of a few symbols, might give the whole of the details required for constructing the line, without involving further labour than the present system does.

This would be found of considerable service for office reference after the line was completed, for it would be directly comparable with the complete Ordnance maps, and exact facts referring to any portion of the line could be obtained at a glance.

For this a narrow book about 12 inches long is needed, with three parallel lines ruled down the centre of each page. These lines represent the road to be followed, and the particulars may be filled in as represented in attached sketch.



The outer lines represent the road boundaries, and the middle one, the centre of the road. Curves are represented by the angles < > according to the direction. These angles may be made to express the amount as well as the direction of the pull on each pole. Spans are measured and represented along the centre line. The poles are shown by dots inside the outer line which bounds whichever side of the road may be adopted, the length being entered close to the dot. Offsets are entered outside the corresponding line. Poles are represented thus A, and strutted poles thus ⅄, whilst stays have a line added to the angles denoting the curve thus ≻. Notes as to property and consents, together with names of roads, streams, and other particulars, are written in the margin.

A convenient scale for such a plan would be the usual division of a foot into 100 parts, which appears on the edge of an ordinary foot rule, although a flat rule so divided would of course be used in practice.

It would be convenient for each page of the survey book to contain particulars of one mile of line. On this scale with a book 12 inches long, each one hundredth division would represent a length of 20 yards, and space would thereby be given for all needed particulars, the mile length occupying a little over 10½ inches of the page. Naturally, any desired scale might be adopted in practice.

A few general remarks as to the principles to be observed in laying out the line, may be allowed to close this division of the subject.

First and foremost comes the question of spans, or in other words the number of poles to be used per mile. This, as might be imagined, varies very greatly according to the views of the engineer and the varying local circumstances.

In the early days of telegraphy, poles were planted regularly 55 yards apart, from end to end of the line, thus giving 32 poles to the mile. The spans were, however, gradually lengthened, until as few as ten poles, giving spans averaging 176 yards, have been used.

In the present day, however, the number of poles for roads may be said to vary from 20 to 26 per mile, and although in some special cases more have been used, the latter number may fairly be regarded as a maximum. In straight lengths poles can be placed from 70 to 100 yards apart, according to the number of wires the lines will have to carry, but on curves this distance frequently has to be reduced to 60 yards. It must always be borne in mind, that increasing the number of poles per mile, whilst giving greater stability to the line, decreases the insulation, by multiplying the points of leakage. The mechanical advantage therefore involves an electrical disadvantage, and judgment must be exercised to obtain the mean of both.

In laying out the line, great care must be taken to set the poles well clear of all road traffic, so that there may be no danger of vehicles running against them in the dark. They should be clear of watercourses, so as not to impede the drainage of the road. The line of wire generally has to follow the windings of the road more or less, but in some cases where there is ample waste, a choice exists as to the method of passing the curved portions. Either the line can be placed symetrically with the curve, thus forming, as it were, a concentric arc,

each pole taking an equal amount of the lateral strain; or two points being taken at the extremity of the curve for poles, which will bear all this strain, the line is struck straight across, forming a chord to the arc. With a slight curve the latter is the most advantageous method, other things being equal; with sharp curves the former becomes imperative.

All poles placed at angles should be entered for struts or stays; struts when the direction of the pull is from the thoroughfare, stays when to it. As a rule stays are preferable to struts; they are more economical, more efficient, and more sightly, but it is not well to use them in the former cases, as they become invisible on a dark night, and dangerous to vehicles passing by. Struts may be replaced by A or double poles, a subject treated more at length further on. The side of the road chosen must depend to a great extent on the waste ground available, on the number and size of the trees lining the banks, on the proximity of houses, &c., so that frequently these considerations leave no alternative which side shall be occupied. When there is no room for choice, however, that side which, on tortuous roads, is the inside of the curve, or which causes the strain to be from the road, involves less danger of a wire obstructing the thoroughfare through any breakage. With heavy lines, however, in which all such poles are stayed or strutted, this choice, by substituting struts and A poles for stays, makes the line more costly, and less sightly. When poles are well stayed, and the line constructed with all modern improvements, there should be little danger of wires dropping across the thoroughfare. Frequent crossings of the highway, should, however, be avoided, as however well constructed a line may be, it cannot be insured from a wire breaking by frost, and such breakages may become an indefinite source of danger. Generally the side with the most room, in the shape of waste ground, or good banks, and the fewest trees and houses, is that to be selected. Poles should not be so planted as to carry wires directly over chimneys, as the smoke will, inevitably, cause them to rust and break away quickly at such points.

The height of the poles is another matter for careful consideration. The main or average height of poles now used on trunk roads, is 28 or 30 feet. At crossings, gateways, &c., a greater length must be used, dependent on circumstances. Where there is wheeled traffic passing under wires, a minimum height of 20 feet between the lowest wire and the ground should be maintained. Allowing a foot between each vertical wire, two feet for the dip if in the middle of a span, the depth in the ground plus 20 feet, will, in such cases, give the minimum height. When rising or falling from one length to another, violent extremes should be avoided, as giving an usightly appearance to a line. Poles should vary by regular increments of four or six feet. In towns and villages the greatest difficulties an engineer has to encounter are to be met with, and herein he shows his tact and judgment most to advantage in overcoming artificial objections. If the line has to be carried through on poles, he obtains a plan of the town, and mounts the most lofty eminence available, which gives him a bird's-eye view of the whole locality. There he traces his course, seeks the least fashionable quarter of the town that is available, uses lofty poles, chimney stacks, and occasionally spires, and avoids, whenever possible, fixing poles on roofs. The line should be kept well above the windows of dwelling houses when passing in front of them, and should be erected so as not to impede the action of fire escapes. General instructions can scarcely be laid down for carrying open main trunk wires through towns. It is, however, scarcely advisable to attempt to run a large number of heavy wires over very lofty buildings, as, where this is done, it results in continued heavy expense in removals, alterations, and repairs to roofs.

Some main lines have been carried very successfully through towns, with open work, by the use of ornamental iron poles. This is preferable to a resort to underground work, but it is very costly, far beyond that of an ordinary wooden line. In such cases the line of street is generally followed, and the wires are not carried over dwelling houses. The poles are generally fixed in the curb, and are sometimes used as joint telegraph and lamp-posts.

THE QUADRUPLEX TELEGRAPH.*

By F. W. JONES.

JUST one hundred years ago George Louis Lesage, of Geneva, constructed a telegraph composed of twenty-four line wires, corresponding to the twenty-four letters of the alphabet, and by the use of frictional electricity and pith balls, succeeded in transmitting intelligible signals over the wires to a distance.

Numberless experiments by different philosophers followed in quick succession with a view of establishing means of rapid communication between widely-separated places, but none of the systems that were devised proved anything more than scientific toys.

It remained for Morse, in 1844, to establish a system which was to stand the test of actual experience.

During the same year considerable activity in experimenting was also manifested in England. The first line of any length was constructed between London and Gosport, on the London and South Western Railway, but it was two years later before lines were extended for commercial purposes.

In our own country, starting with one wire between Baltimore and Washington in 1844, we can now boast miles enough of telegraph wire, owned by the various companies, to encircle the globe about ten times. Chicago had its first wire in 1847, and now the Western Union Chicago office alone works 72 long circuits stretching in every direction to all parts of the country, besides 30 metropolitan and 60 private lines.

So far from adhering to first principles in the use of *twenty-four wires for the transmission of a single message*, the hour is at hand when *twenty-four messages can be transmitted simultaneously over one wire.*

At the present time four messages are sent at the same time a distance of nearly one thousand miles, with the utmost ease and certainty, at the rate of 120 words per minute.

* Read before the meeting of the American Electrical Society, at Chicago, Ill., February 17, 1875.

The wonderful instrument performing this miracle in telegraphy is *The Quadruplex*, an invention of Messrs. Prescott and Edison, electricians. It is based on the same principle as the Bridge Duplex, comprising all its main features, and in order to render a description of the Quadruplex easier and more comprehensible, I will briefly review the duplex system. Authors do not agree in their account of the origin of the duplex; some refer it to Dr. Gintl in 1853. It is well established, however, that experiments were made by the Electric Telegraph Company, of England, in 1853, but their system did not prove of any advantage, and it fell into disuse. About the same time Gintl, Siemens, and Prischen directed their efforts towards perfecting a duplex, and many Russian stations were fitted up with their instruments; but, from the fact that no gain was realized over single transmission, the stations were refitted with the ordinary Morse. Mr. De Sauty, in 1855, successfully worked the Frischen-Siemens system between Manchester and Altringham. *He only accomplished ten words per minute against sixteen by the single Morse.*

In 1856 attempts were made to work the duplex between London and Birmingham, on the Magnetic Company's wires, and the signals were improved by using a condenser; but the experiments ceased, for the reason that Mr. Gordon, of the firm of R. S. Newall and Co., to whom the English patents belonged, did not deem the addition of condensers of sufficient value to warrant the expense of their construction.

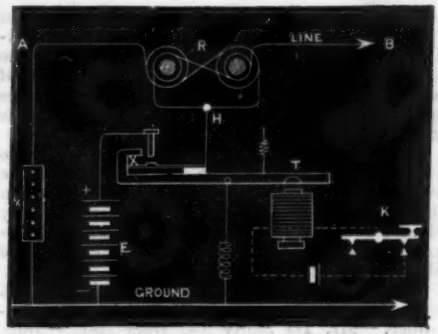
In 1868 the duplex was revived by J. B. Stearns, of Boston, and was actually worked on one of the wires of the Franklin Company. His system, which I will now describe, does not differ materially from those that have preceded it, save in the application of an improved form of double pointed key or transmitter, and, more recently, condensers, whereby long line difficulties were entirely overcome, and the carrying capacity nearly doubled.

A relay is wound throughout with two separate wires, the outer end of one and the inner end of the other are brought directly to the double pointed key. One of the opposite ends of these wires is connected to the line, and the other to a rheostat and ground of resistance equal to the resistance of the line.

The transmitter, or double pointed key, is arranged to be in contact with battery when the lever is depressed, and with ground when elevated—one contact always taking place, through spring contrivances, before the other ceases; thus the line is always on battery or ground.

Supposing B, the distant station, to have his key open, the transmitter, which his key opens, keeps the line grounded through one wire of his relay. When Station A closes his transmitter, the current passes therefrom to the relay, and there divides in two directions; one part goes by one coil of the relay to line, and the other part by the second coil of relay to rheostat and ground. The resistances being equal in these two directions, an equal quantity of current flows through them; but, as they pass oppositely around the core no magnetic effect is produced, and the armature is not attracted from the back stop.

The current arriving at station B passes through one coil of his relay to transmitter and ground,



causing his armature to move forward and close the recording sounder. At this moment, should B close his transmitter he will divide his battery between rheostat and line, as was done at A, and feel no effect from it upon his own armature—one part exactly neutralizing the other; but currents being on the line, there is now double the quantity there was when B was open, consequently through the line coil of either relay, there is more current than there is flowing through the rheostat coils; therefore the cores of each relay become magnetized by this difference, and signals are recorded simultaneously at each station.

As soon as the system was tried on long lines a kick was experienced on the armatures, rendering the signals totally unreliable. This was caused by the discharge of return current through relay, and depended for volume on the static capacity of the line. A familiar illustration of this may be had by supposing a straight pipe to connect two points in the same plane, and at one end of the pipe water is forced through at a high pressure; if the pressure is suddenly removed and the pipe left open at each end, part of the water in the tube will return and empty itself, in preference to overcoming the friction of the distant portion of the tube.

Electricity, in a long and well insulated conductor of large metal cross section, will flow through to the distant end and to ground so long as battery contact is maintained; but let the battery be suddenly removed and a ground substituted, part of the charge at that instant left in the conductor will return to ground in preference to passing through the whole resistance of the line to the farther end. This return is the kick that causes so much vexation to telegraphers. By the use of condensers the kick has ceased to annoy, and five hundred mile circuits are now worked as well as those of one hundred.

It will be readily comprehended that the few coils of fine wire of which a rheostat is composed have not the static or charge capacity of a long line, the metal of one weighing only a few ounces, that of the other perhaps a hundred tons of a superior conducting metal, therefore no return charge or kick is felt from the rheostat; but by attaching to the rheostat a condenser whose static capacity is nearly equal that of the line a charge will be returned from it, at the same moment that the battery charge returns from the line, thus destroying all kick in the relay by neutralizing each other's tendency to magnetize the cores.

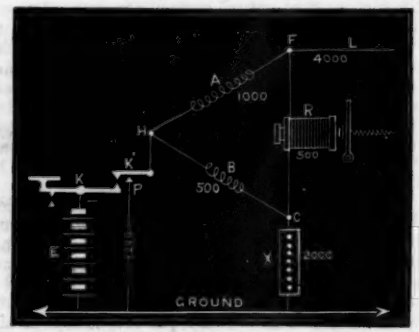
This system can be worked as well with the *same*

poles of battery to line as with opposite or "agreeing" poles. When both stations send positive currents they neutralize each other on the line side, allowing the currents in the rheostat coils of relays at the home ends to move the relay tongues and record the signals, the same as if both currents combined on the line.

Next in order to the differential duplex comes the bridge duplex, founded on the principle of the Wheatstone Bridge. This method was adapted on the Gibraltar and Lisbon cable in April, 1872, by Mr. De Sauty, the electrician of the Eastern Telegraph Company at Gibraltar, at the suggestion of Mr. W. H. Preece, of England.

The length of the cable is 360 nautical miles, and worked by mirror galvanometer and syphon recorder. Mr. De Sauty was from March 16th, 1872, until April 11th of same year before he made it a success, so much trouble being felt from the static discharge; this he overcame by making his rheostat circuit similar to the cable in static capacity, dividing his resistance, and interspersing his condensers, so that they would return a proper charge at the exact time it was returning from the cable. Thus he made himself master of the situation, and has since duplexed other cables, including the Mediterranean cable from Gibraltar to Malta.

In the *Journal of the Telegragh*, Sept. 1st, 1873, is described the bridge duplex as a recent invention of J. B. Stearns, of Boston, and as this system is intimately connected with the quadruplex, a brief notice of the former is necessary to make plain the latter.



The bridge duplex embodies the principle of the Wheatstone balance, wherein a current dividing between two circuits, which are connected by a cross wire or bridge, no current will flow over the bridge if the resistances of the circuits on each side of the bridge are equal, or be the same proportion to each other.

By reference to the diagram it will be seen that when transmitter K is closed the current it sends out will divide at Point H; one part going over line and the other part *via* B and rheostat to ground. Now, if the resistance of these two circuits is equal no current will pass over the bridge wire F C, consequently the relay R will be unmoved. When the current arrives at distant end it divides at F, between the transmitter and rheostat X, in inverse proportion to the resistance of respective routes; the portion passing through F C operates the relay R, and records the signals, and so when distant station closes his transmitter a double amount of current flows through the line, producing unequal tensions in the line and rheostat sides of the bridge, causing a current to flow across each bridge and close the relays, recording signals at each end simultaneously.

Towards the close of 1874 it was noised abroad that a quadruplex had been put into successful operation between New York and Boston by Messrs. Prescott and Edison, electricians. More recently it has been put into actual use between New York and Chicago, through a repeater at Buffalo, and between Chicago and Cincinnati — the former distance being nearly one thousand miles, the latter three hundred miles. As previously stated, it has for its foundation the bridge duplex. In the bridge wire of the duplex there are two relays — one is a common relay of very short cores and moderately low resistance, capable of being affected only by strong currents. The other is a Siemens polarized relay, which is sensitive to feeble currents, and is so constructed as to allow the tongue to be thrown on the back or open stop when a current of a certain polarity passes through its coils, and on the front or closing stop when a reverse current passes. There are two separate transmitters brought into use in double transmission from either end. The double transmitter is a pole changer having one spring connected to line and the other to ground. The contacts with each spring are connected crosswise with the smaller portion of main battery through the spring and lever of the single transmitter, which has an additional section of battery inserted between the lever and its closing contact point. When both transmitters are open the smaller part of the battery will be presented to the line. The current flowing therefrom will divide between the sides of the bridge—one part passing to rheostat and earth, the other passing over line and dividing between the bridge wire and the transmitter ground at receiving end. The portion crossing the bridge will push the tongue of polarized relay on the back stop, but will not affect the common or neutral relay for reasons before stated. If the double transmitter at sending end be closed the same portion of battery is reversed in circuit, deflecting the tongue of polarized relay at distant end to the front or closing stop, thus recording a signal. The second transmitter merely cuts in or out of circuit an increased portion of battery, sufficient to close the distant common relay, and the movements of the first or double transmitter wholly determine the polarity sent to line; when the double transmitter is up and the single one closed the latter cannot record a signal on the polarized relay at the remote station, for the reason that the current is of the wrong polarity; the same effects take place at the home station under similar manipulations at the distant end. Here then is the curious possibility of one operator having his key open, a second his key closed, the third making a dot, and the fourth a dash at the same time, and the respective positions being recognised fully at opposite ends.

Under the supposition that the batteries are divided into proportions of 50 cells and 150 cells the following changes of polarity and quantity will take place on the line during transmission from both stations:—50 plus and 50 minus, 50 plus and 50 plus, 50 plus and 200 minus, 50 plus and 200

plus, 50 minus and 200 plus, 200 minus and 200 plus, 200 minus and 200 minus, 200 plus and 200 plus.

These constant variations and reversals taking place through the relay coils tend to produce in them an unsettled magnetic condition, causing the movements of their armatures to be unsteady and unreliable for signals. To remedy this the bridge wire is supplied with a condenser which is charged by the same currents that work the relays, and so soon as they are withdrawn from relays the condenser discharges before a reversed current reaches them, thus prolonging the signals and preserving a magnetic equilibrium of the cores.

The condensers connected to the equating rheostat require the nicest adjustment to exactly neutralize the static discharge from line. Compared with the differential system the percentage of effective signalling current on the quadruplex is very low, and is divided between two relays in the same circuit, therefore the utmost care is necessary in balancing and arranging the different adjustments to bring out its full value. During actual service it requires great vigilance and an intelligent supervision, else it will fail to even duplex the capacity of a wire. When depended on to do the work of four wires it will be readily seen how grave would be the smallest delay, hence it behoves managers to familiarize themselves thoroughly with every part, in order to render the proper service of the quadruplex to the companies by whom they are employed.

Other methods of quadruplexy have been devised, but have proved of no practical value. That of M. Meyer, of the French Telegraph administration, exhibited at the Vienna Exposition, is the most notable, transmitting four messages over one wire in the *same* direction, but its best performance was only 110 ordinary messages per hour. Dr. H. C. Nicholson, of Mt. Washington, near Cincinnati, has also constructed a quadruplex for transmitting two messages in opposite directions over one wire at the same time. His system is on the differential principle. The outgoing currents passing in opposite directions around the home relay produce no effect on its cores. Two keys are used and are so arranged as to send current to line in the following order: When one key is depressed a positive current of given tension, when the other is closed a negative current of equal tension; when both keys are closed simultaneously a positive current of double the tension of that sent by a single key.

The relay has horizontally, and side by side, two straight cores wound differentially, and at either end are permanently magnetised armatures. One is placed horizontally on a tongue in front of the poles at one end, and the other armature swings vertically on an axis between two semi-circular extensions of the poles opposite those facing the first described armature. Both armatures are so polarized that when one is attracted by a current of certain polarity passing through the coils the other is repelled. In order to balance for work, the distant station is asked to open both keys. This removes his batteries and grounds the line through his instruments. At the home station dots are struck on either key, and the equating rheostat is so adjusted that an even division of current is made through the relay between line and ground, neutralizing all magnetic effect in the cores. Condensers must be used for static discharge the same as in duplex system. The distant station is now asked to dot on positive key, which sends a current attracting the corresponding armature at the home end, closing the local points and recording a signal. Then the distant station dashes on the negative key, closing the armature of home relay at the end opposite the one operated by the positive key, and recording a signal on sounder by contact. When both keys are closed at once the tensions of their batteries are doubled and of positive polarity. This causes a double force to act on the agreeing armature which presses forward a spring, thus closing not only its own sounder, but also the one in the connection with the opposite armature recording signals simultaneously. The weak points of this system seem to lie in the constant and uneven reversals of the current during transmission producing an unsettled condition in the cores; uncertainty of action between the armatures, and the imperfect mechanical contrivance for transferring the operation of the sounder from one tongue of relay to the other.

What may yet come of this system is a problem for future solution. It has worked moderately well on a rheostat circuit of 6,000 ohms, but has disappointed the expectation of its friends on an actual line circuit, probably on account of its infancy and want of a thorough test.

Notes.

THE Western Union Telegraph Company have declared their quarterly dividend of 2 per cent., payable 15th July next. The net earnings of the Company for the year ending 30th June, 1875, are set down at 3,912,484.59 dols., the months of May and June being estimated.

On the 8th instant the number of messages passing through the chief London Telegraph Office amounted to 36,550, and on the 9th to 36,544, being the highest number yet dealt with during 24 hours.

The International Telegraph Conference is progressing with its labours. Committees have been formed, whose duty it is to sift the various questions before they are brought under the consideration of the Conference. One of the most important innovations debated in the first few conferences has been the proposal to introduce urgent messages which would take precedence of ordinary messages in international telegraphy, and would, of course, be subject to a higher rate of payment. Another important proposal aims at the adoption of ten-word messages for European telegraphic correspondence, with gradation by the same or a less number of words, or by single words. Other modifications have also been proposed, having for their object the reduction of the existing minimum number of words, with a corresponding reduction

in price. At the same time entertainments of various kinds continue to be organised in honour of the delegates. Amongst other places of note, the Central Telegraph Station at St. Petersburg has been visited. One thing in connection with this establishment will be interesting to many of our readers. The young ladies employed on the telegraph staff wear a kind of uniform dress, green, with orange-coloured piping, cut to resemble a high double-breasted waistcoat. It strikes us young ladies on the London staff will not view this idea with any great amount of favour; at all events, we do not anticipate its speedy adoption by them. The telegraphists (men) are also in uniform of a military type. Sir James Anderson, Managing Director of the Eastern Telegraph Company; Mr. Clare, Secretary of the Submarine Telegraph Company; and Mr. Andrews, of the Indo-European Telegraph Company, have recently arrived to take part in the Conference.

The Sultan of Zanzibar visited the General Post Office, and inspected the telegraph branch of the establishment. Lord John Manners and Mr. Scudamore received the Seyyid, the latter pleasingly bringing under his visitor's notice all the many interesting features of the building. Being invited to send a message, the Sultan addressed the following enquiry to his consular agent at Aden, "What is the latest news from Zanzibar?" and in a short time received the following reply, "Nothing of importance—all well. Your message and letter sent to-day per Coconada to Zanzibar—compliments." Having recorded the fact that on the 18th day of June, 1875, he, Seyyid bin Saed, had visited the telegraph department of the English General Post Office, the distinguished visitor took his departure. The postal department was not inspected, because at that hour the several operations which make it attractive were in abeyance.

At a recent race meeting over 400 messages were received from London in one batch with only one stoppage, for fresh paper, by Wheatstone Receiver.

The cable between Punta Rassa and Key West (U.S.), announced in our last as having been interrupted, is repaired, and messages are forwarded as usual.

The new cable making at the Silvertown Works, to duplicate this section, is nearly completed, and will shortly be despatched.

The Eastern Telegraph Company (Limited) announce that, subject to the final audit, the accounts show a balance available for dividend which will enable the directors, at the general meeting on the 13th July, to recommend the declaration of a final dividend of 2s. 6d. per share, making, with the previous payments on account, a dividend for the year ending 31st March of 5 per cent., carrying to reserve a balance of £36,000.

RESISTANCES AND THEIR MEASUREMENT.

By H. R. KEMPE.

XVII.—*Measurement of Resistances by fall of Charge.*

One principle of this method of measurement is that of observing the rate at which a charged condenser of a known electrostatic capacity discharges itself through the unknown resistance, and calculating the resistance from a formula which we are now about to obtain. The elements with which we have to deal, are capacity (farad), resistance (ohm), quantity (vebu), time (second), and potential (volt).

Let us suppose the condenser has an electrostatic capacity of C farads, and is charged to a potential of V volts so that it contains Q vebus (equal to V C) of electricity, and is discharging itself through a resistance of R ohms during t secs.

Now the quantity of electricity in the condenser at starting is Q vebus.

Then if we take a very short interval of time t we may consider the discharge, which really continually varies, to continue to flow throughout that time t, at the same rate as it had at the commencement of the time, and the smaller t is taken, the more accurate will be the result. Thus since the quantity escaping is directly proportional to the potential driving A out, and to the time during which the escape occurs, and inversely proportional to the resistance through which the escape takes place, the quantity escaping will vary as—

$$\frac{V\,t}{R} \text{ that is, it equals } \frac{V\,t}{R}\,K$$

where K is a constant to be determined.

Now the units are so made that a condenser of 1 farad electrostatic capacity charged to a potential of 1 volt, that is containing 1 vebu of electricity, will commence to discharge itself through a resistance of 1 ohm, at the rate of 1 vebu a second. That is to say—

$$1 = \frac{1\times 1}{1}K, \text{ therefore } K=1.$$

The quantity escaping during the interval of time t in our problem is therefore—

$$\frac{V\,t}{R}$$

The qnantity remaining in the condenser will be—

$$Q-\frac{V\,t}{R}=Q-\frac{V\,C\,t}{C\,R}$$
$$=Q\left(1-\frac{t}{C\,R}\right)$$

Again since this is the quantity at the commencement of the 2nd interval, that at the end will be—

$$\left[Q\left(1-\frac{t}{C\,R}\right)\right]\quad\left[\left(1-\frac{t}{C\,R}\right)\right]$$
$$=Q\left(1-\frac{t}{C\,R}\right)^2$$

and that at the end of the nth second will be—

$$Q\left(1-\frac{t}{C\,R}\right)^n=q$$

Now let these n intervals of t seconds equal T, so that $n\,t = T$. Now we have seen that the smaller t is the more accurate will our results be. Let us then make $t = o$ and $n = \infty$, so that $n\,t$ still $= T$, then we shall get a perfectly accurate result, and the amount remaining at the end of time T will be—

$$q = Q\left(1 - \frac{T}{N\,C\,R}\right)^n$$

where $n = \infty$

To evaluate q put

$$\frac{T}{n\,C\,R} = -\frac{1}{X}$$

so that

$$x = \infty \text{ when } n = \infty$$

then

$$q = Q\left[\left(1 \times \frac{1}{x}\right)^{x}\right]^{-\frac{T}{C\,R}}$$

when $x = \infty$, but when this is the case the expression within the square brackets is known to be equal to z, thus—

$$\frac{q}{Q} = z^{-\frac{T}{C\,R}}$$

thus—

$$\frac{T}{C\,R} = \text{by } {}_z\frac{Q}{q}$$

therefore—

$$R = \frac{T}{C \text{ by } {}_z\frac{Q}{q}}$$

but—

$$\frac{Q}{q} = \frac{V\,C}{v\,c} = \frac{V}{v}$$

where v is the value of the potential corresponding to the value q of the quantity, thus—

$$R = \frac{T}{C \text{ by } {}_z\frac{V}{v}}$$

where, as stated at outset, t is measured in seconds, c in farads, and r in ohms. V and v, although measured at the outset in volts, as they now appear in the form of a proportion, the unit in which they are measured is immaterial, and this constitutes one of the values of the formula.

In practice C is usually measured in mirrofarads ($\frac{1}{1000000}$ farad), and consequently R will, in such a case, be measured in megohms (1,000,000 ohms).

Example.

A charged condenser of ·3 microfarads capacity gave a discharge deflection of 300° when full, after being recharged and allowed to discharge itself through the resistance for 60 seconds, the discharge deflection given was 200° to determine the value of the resistance.

$$R = \frac{60}{\cdot 3 \log. \frac{300}{200}} = 126 \text{ megohms.}$$

Inasmuch as the fall of charge would be rapid through a low resistance, this method is only applicable to high resistances like the dielectric of a cable. When the insulation resistance of a cable is measured by this method, the result obtained is the mean of the resistance which it has at the beginning, and which it has at the end of the experiment, as *electrification* goes on the whole time the experiment is being made.

The A cable acts both as the condenser and resistance. We should just, therefore, have to determine its electrostatic capacity, which we should do by the ordinary method of comparing the discharge deflection obtained from it with that obtained from a standard condenser.

If we know the potential the cable has when full charged, and also its potential after a certain time, we can determine the potential it will have after any other time.

Now a charged cable loses equal percentages of its charge in equal times, that is to say—if, for example, 5 per cent. of its charge during the 1st second, it would lose 5 per cent. of *what remained* in the second second.

Let V be the potential at first
v " " after 1 sec.
v_1 " " " t_1 "
v_2 " " " t_2 "

and let us suppose the charge lost $\frac{1}{N}$ th of its potential during the 1st second, then potential left at the end of first 2nd will be—

$$V - \frac{V}{n} = v = V\frac{v}{V}$$

potential left at end of 2nd section will be—

$$v - \frac{v}{n} = v$$

but from last equation—

$$n = \frac{V}{V\,v}$$

therefore substituting j we get—

$$\frac{v^2}{V} = V\left(\frac{v}{V}\right)^2$$

and consequently potential left at the end of t_1 seconds will be—

$$V\left(\frac{v}{V}\right)^{t_1} = v_1$$

and also—

$$V\left(\frac{v}{V}\right)^{t_2} = v_2$$

therefore—

$$t_1 = \frac{\log \frac{v_1}{V}}{\log \frac{v}{V}}$$

$$t_2 = \frac{\frac{v_2}{V}}{\log \frac{v}{V}}$$

that is—

$$t_2 = \frac{\log \frac{v_2}{V}}{\log \frac{v_1}{V}} \quad t_1$$

The logarithms may be either natural or common ones, thus, for example, if the potential at first was 300 (V) and after 20 secs. (t_1), it fell to 200 (v_1), after what time would it fall to 100 (v_2)?

$$t_2 = \frac{\log \frac{100}{300}}{\log \frac{200}{300}} \times 20 = 54 \text{ secs.}$$

It being usually required to know the time the charge in a cable will fall to half tension the formula becomes

$$t = \frac{\cdot 30103}{\log \frac{V}{v_1}}$$

It will be readily understood that the formula for determining the resistance from fall of charge will also enable us to determine the electrostatic capacity of a cable from fall of charge. In this case the formula would be

$$c = \frac{t}{R \log \frac{V}{v}} \text{ minufarads}$$

The connections for making either of these tests for a cable would be precisely the same as those used in making a capacity test. The second trigger of the discharged key described would here come into use. Having first charged our cable and taken the immediate discharge by pressing down the left-hand key we should again charge it, and this time press the right-hand key down, which would take the battery off but not discharge the cable. After a certain interval of time, which is noted, the left-hand key is depressed, which gives the discharge of the remaining portion of the charge.

(To be continued.)

THE ADJUSTMENT OF MORSE INSTRUMENTS.*

By H. W. JENVEY.

I SHALL endeavour to avoid the theoretic aspect of adjustment as much as possible, and when I do mention it to do so as plainly as I can.

We may divide a Morse instrument into three parts—the relay, the register, and the key.

I.—THE RELAY.

I take this first as being, I consider, the most important part. We all know how important it is when a line is working badly through damp weather, etc, to have a good adjustment of the relay, or, in other words, to get as much power out of it with a given amount of current as possible. I find the best way, on coming to an instrument on a line which I know to be working badly, is to raise the spring to its highest limit, then to screw the magnet as near the armature as possible without closing the local circuit (this may be arrived at by trying the magnets forward and back till the adjustment is just above closing point), and then to adjust down with the spring till I either find some one working, or am assured that the line is silent. After this adjust with the spring for the station sending, unless the adjustment varies very much. Before doing this I should have mentioned that it is most highly important to see that the contact points of the relay are perfectly clean and smooth. They may be made so by taking out the front stop and rubbing the point on a piece of wood till quite bright and clean, and the small platinum plate on the armature should be cleaned from any specks which may be on it with a knife, and rubbed bright. A very fine watchmaker's file is an excellent thing for this purpose. The points, having been cleaned and smoothed, should now be screwed as closely together as possible, without causing the armature to stick. This can be ascertained by opening the key, and then screwing the points as close together as possible without closing the local circuit. These precautions having been taken, and granted that the relay is a fairly good one, the line must be in a bad state indeed if you cannot get signals from the other stations.

The reason why it is advisable to have the spring as tight, and the magnets as near to the armature as possible, consistently with being in adjustment, is that the power developed in the magnets for moving the armature is used to its best advantage, and the power of the spring to draw the armature away, when the key of the sending station is opened, is exercised more immediately than if it were comparatively weak, thereby making the armature follow the action of the sending key in a firm and decisive way.

For, suppose that I am adjusting for a station, and find that I can adjust the magnets $\frac{1}{16}$ of an inch from the armature when I have the spring screwed up to its full pitch, it is evident that it will work much firmer with this strong pull on each side than if I have the magnets half-an-inch off the spring, hanging loose or next door to it, when the pull on each side is almost nil. There is a certain amount of inertia in the armature of the relay, which, in the first instance, is almost entirely overcome by the strength of the spring and attraction of the magnets, but which, in the second instance, is a great deal too much for either to work it. These are, of course, extreme instances, but they serve to illustrate the rule. There is another thing in favour of the way of adjusting that I advise, and that is, that the vibration from the movement of the armature of the register, and any chance vibration in the room, both of which are conveyed by the table to the relay, and shake it, have not nearly the disturbing effect upon the movement of the armature that they have when the relay is loosely adjusted. When the string is too long to allow the magnets to be screwed close up, a piece of it should be taken off. I recollect one of our colleagues coming to me one day and saying, "See what's wrong here; I can't get anyone's writing, yet I think the line's right." This was one of the best working lines in the office, so I suspected something wrong in the adjustment, and found the magnets of the relay far away from the armature, and the spring hanging like a slack clothes-line. I screwed up the points, the spring, and the magnets, and behold writing came admirably. I found afterwards that he could not even get his own writing on the instrument. The fact was, that as he had the instrument adjusted neither the spring nor the magnets had sufficient strength to stir the armature, while every vibration in the room set the instrument jarring like a clock running down.

It is advisable, also, to see that there is a good contact between the pivot points of the armature and the brasses which hold them, so that the local current may be uninterrupted there. This is a frequent cause of an instrument working badly. It is best, also, to have the position of the armature as perpendicular as possible, as there is less liability to stick.

I think we may now turn our attention to number

2.—THE REGISTER.

The same remarks which I have made about the relay, with regard to the nearness of the magnets to the armature, are applicable here. The magnets should, by some means, be made perfectly firm, and the armature adjusted down to them, rather than the magnets to the armature. If the magnets are not firm they will jump and give a drubbing sound when the instrument is working. The spring may be tightened according to the liking of the operator for a hard or soft sound, as

* Read before the Telegraph Electrical Society, Melbourne.

the tighter the spring the stronger the stroke against the back stop. There is one great difference between the adjustment of a relay and a register; and that is, that the adjustment of a relay is constantly varying from the different kinds of weather and other causes, but the adjustment of, at all events, the magnets of a register need never be shifted after they are once placed at their maximum point of attraction consistently with the armature working well. Any subsequent variation in the attractive power of the magnets, which will be caused by a weakening or strengthening of the local battery, may be compensated for by shifting the screw of the spring as may be required. If a line is working badly, and a fine and high adjustment of the relay is necessary, the armature will often jar. This arises from the vibration caused by its movement shaking the armature of the relay to and fro, and opening and closing the local circuit, independently of what is being done in that way by the sender. The best way to avoid this is to screw the back-stop of the armature of the register down till the beat of it is lessened as to no longer shake the relay; at all events, try to get as near that as possible, consistently with getting a tape mark. This is one reason why ink instruments are preferable to embossers on a bad line, as the register armature will make a mark, and work with less play than an embosser. Where the instrument is an embosser, great care should be taken to keep the steel embossing point exactly in the centre of the groove of the roller, as then the best possible tape mark is obtained, and the sound is less interfered with than if the point grazes or strikes against the roller. Very little care is taken by sound operators, as a rule, to keep a good tape mark, but a little trouble will sometimes repay itself doubly, especially in looking up a message afterwards, as it must be remembered that every time the tape passes through the rollers the previously embossed lines get another flattening, and therefore the deeper the mark at first the better it survives the squeezes it gets afterwards. The discs of ink instruments should be kept perfectly free from accumulations of dust, lumps, etc., and particular care taken that they only sufficiently press the tape to make a mark and no more. If they batter against the steel bar, against which the disc strikes the tape, the edge becomes corrugated and makes a very bad mark, and the sound is also interfered with. In embossers the screws confining the pivots of the armature should be sufficiently loose to let the armature have free play, and sufficiently tight to ensure its remaining in its proper place. Where an instrument repeats on to another by the register, it is of the highest importance to keep the point of the front stop of the register and the contact piece of the register armature perfectly clean, and to close the front and back stop as near as possible without sticking, and without preventing the attendant from hearing when a break occurs.

I may as well remark here that in running tape through it will be found advantageous to be systematic; say, to always have the first line at the top of the tape, and the second next below it, and the third below that, and never to use a tape for more than three lines. The advantage of this will be found on any reference to the tape afterwards.

I should like to express here a dislike I have to the system of regulating the magnets of the register by means of the screw which is provided for that purpose on the latter supplied instruments. I believe it to be not only totally unnecessary, but a nuisance, and if the magnets are jammed down tight and left there the instrument can be adjusted to them. Lastly we arrive at

3.—THE KEY.

There is little to be said about this beyond pointing out the necessity of having the contact points perfectly bright and smooth. The degree of pull in the spring and the distance between the points are matters of taste; but I think that better sending is obtained in most cases from a well opened key and a moderately slack spring than from a key jammed almost to the sticking point, and a spring with a pull of some pounds more or less. Care should be taken that the key works very freely on its pivot; otherwise, it will retard freedom in sending.

To sum up: the pleasure and ease in working derived from a little care in adjusting repay any trouble undertaken, and to point out a few main principles of adjustment is my apology for having read this paper.

Mr. D. J. McGauran, at the conclusion of the meeting, exhibited a model of his own construction, showing the working of the duplex system of telegraphy.

The model worked admirably, and excited a great deal of interest.

INDIA-RUBBER.

THE composition of India-rubber, as determined by Faraday, is 87·2 per cent. of carbon and 12·8 of hydrogen.

In its natural state it forms part of the milky sap of various species of trees, which are to be met with in tropical regions, its synonym, caoutchouc, being derived from the caoutchouc tree, which is chiefly to be found in Central America, and was for some time the source whence the main supplies of the article were drawn. The trunk of the tree is periodically pierced—in some instances as frequently as once a fortnight—and the sap as it issues is either caught in vessels placed for the purpose, or allowed to accumulate in a hole dug round the foot of the tree. The liquid may be prepared for export in two ways. Either balls of clay are inserted into it, then passed over a fire, until the India-rubber which they have taken up hardens, re-dipped, and have the same operation repeated upon them, until a certain thickness is obtained; or a piece of wood is employed, around which the sap accumulates, and from which it is detached after a certain volume has been acquired. The purest India-rubber is prepared in the latter way. With the clay-balls, impurities in the shape of sand, pebbles, &c., are unavoidable.

The first process to which the raw material after its importation is subjected has for its object the removal of all the impurities which have become mixed with the natural gum as it ran from the parent tree. This is effected by sawing it up—after being softened by immersion in hot water—into small pieces of about an inch and a-half square, pressing these betwixt two horizontal cylinders, and keeping a constant stream of water flowing upon them. The irregular sheets into which they are ultimately formed are then dried by being hung where a free circulation of air can take place.

These sheets are then kneaded and heated for the purpose of reducing them to a perfectly homogeneous mass. This is done by means of a horizontal cylinder, along the whole length of which runs a shaft provided with a series of sharp pointed teeth disposed of in alternate rows. Into the free space of the cylinder the India-rubber is introduced, and the entire mass assuming a rotary motion, under the influence of these teeth, is masticated by them until perfect homogeneity is attained. The cylinder was usually formed with a double casing, heated by steam, in order to facilitate the process of mastication, but this is now being abandoned, as the mechanical heat developed is found of itself to be sufficient for the work. By raising the temperature too much, great danger is incurred of rendering the India-rubber soft and viscous, and thereby lowering its value for electrical purposes to a very material extent.

The last operation in preparing the pure rubber is to pass it betwixt the compressing cylinders, which are hollow, heated internally by steam pipes, and arranged horizontally in couples. From betwixt these it finally issues in the shape of a smooth compressed sheet of close texture.

Pure India-rubber is colourless and transparent. It

possesses the power of absorbing water, cannot be dissolved by any dilute acid, nor even by the strongest alkaline solutions; although concentrated sulphuric acid, especially if aided by heat, and nitric acid lead to its decomposition. The best dissolvent known that can be employed is the bisulphide of carbon, with an addition of 5 per cent. of anhydrous alcohol. The elasticity of India-rubber is its main characteristic. At the ordinary temperature it is very elastic, but if cooled it gradually loses this property, until when 35° F. is reached it has disappeared altogether. When heated to about 350° F. it assumes a viscous condition.

Various attempts have from time to time been made to introduce India-rubber as the insulating covering for underground or submarine telegraph wires in place of gutta-percha; but none have been attended with success, leaving out of sight for the present Mr. Hooper's method, which is reserved for future notice. India-rubber possesses several undoubted advantages over gutta-percha, but they are unfortunately more than counterbalanced in the case of pure rubber, at least, by corresponding disadvantages which still remain to be surmounted. Of the advantages of pure rubber the two most important are—

1. Its high insulating power. The resistances of gutta-percha and India-rubber have been made the subject of an immense number of most careful experiments; and although many different results have been obtained, they all agree in assigning to India-rubber, under ordinary circumstances, a higher insulating power than to gutta-percha.

2. Its low specific inductive capacity. Mr. Fleming Jenkin has determined that of gutta-percha to be 4·2, that of india-rubber to be 2·8, taking air as the standard.

Against these are to be urged, amongst other points:

1. The power which india rubber possesses of absorbing water. This is far more manifest in fresh than in salt water, but in both India-rubber offers much greater facilities for absorbtion than gutta-percha.

2. The extreme difficulty of making a sound reliable joint in an India-rubber core. Various methods have been tried—the tapes, the form in which the India-rubber is applied, are wound round the wire, and then consolidated by being immersed in boiling water. In some cases solvents have been applied to join them together. Neither of these methods can be adopted with safety—deterioration of the rubber sets in with both. The plan which met with most favour was that applied by Mr. Siemens, of forming the joint by the adhesion of freshly-cut surface of the tapes subjected to pressure. Yet even this cannot be regarded as a success.

3. The sensitiveness of pure rubber to the variations of temperature is a great drawback to its employment; at low temperature its elasticity, as before remarked, disappears.

In order to overcome as far as possible these objections to the employment of pure India-rubber, *vulcanised* India-rubber has been made use of. It is simply a compound of the pure rubber with from 2 to 3 per cent. of sulphur. In its raw condition India-rubber would appear to consist of two parts—the one compact and elastic, resisting all attempts at solution; the other semi-liquid and readily disolved. Both are well defined, and it is to the latter element that the pecular behaviour of India-rubber under the influence of cold, or when raised to a high temperature, is to be attributed. To obviate this is the object aimed at by the introduction of sulphur. It is partly attained, for not only does vulcanised india-rubbed show less facility for the absorption of water, but it resists alike the extremes of heat and cold, preserves its elasticity under these circumstances, and refuses to be decomposed. Mr. Siemens' experiments upon the relative absorptive powers of gutta percha and India-rubber gave the following results:—

	In fresh water.	In salt water.
Raw India-rubber	25 per cent.	8 per cent.
Vulcanised India-rubber	10·14 "	2·0 "
Gutta percha	1·5 "	1 "

But the difficulty of making a proper joint has not been surmounted.

On the other hand, vulcanised India-rubber, though not affected by temperature like the pure rubber, has a great drawback which the latter does not seem to possess. In contact with the copper wire, it in time assumes a viscous condition, and, under pressure, becomes practically useless for insulating purposes. To resist this, the copper wire is tinned before the india-rubber is wrapt around it.

Taken all in all, gutta percha seems destined to hold its own, as the insulating material in underground and submarine telegraphy for many years to come. In our next number we shall touch briefly on its manufacture and the various properties possessed by it.

THE LIGHTNING ROD MAN.

He drove his team close up to the fence, got down, and rapped at the door. The widow Gilkens opened it, when he said: "Mrs. Gilkens, I am cognizant of the circumstances by which you are at present surrounded, left as you are to trudge down the journey of life through a cold and heartless world—no longer sustained and encouraged by the noble one to whom you gave the treasures of your heart's affection, and bowed down by the manifold cares and responsibilities incidental to the rearing of eight small children on forty acres of subcarboniferous limestone land; yet, Mrs. Gilkens, you are aware that the season is now approaching when dark, dismal, dangerous clouds, at frequent intervals, span the canopy of heaven; and when zigzag streaks of electricity dart promiscuously hither and thither, rendering this habitation unsafe for yourself and those dear little ones; hence, therefore, let me sell you a copper wire, silver tipped, and highly magnetic lightning rod."

The woman staggered back a few paces and yelled: "Narcis! unfasten old Crouch!" In another instant a savage bulldog came darting round the corner of the house with bristles up, thirsting for gore. The dog had already mangled a machine agent and a patent soap man, and was held in great esteem by the better class of citizens for his courage and service; but when his eye met the hard, penetrating gaze of Mr. Parsons, his chops fell, and he slinked off and hid in the currant bushes. Then the man said: "My dear lady, you seem to be a little excited. Now, if you will allow me to explain the probably inestimable—"

"Dern ye, I know what will start ye," said Mrs. Gilkens, as she reached under some bed-clothing, and brought forth a horse pistol; but owing to the shattered condition of her nerves, her aim was unsteady, and the charge of buckshot missed save where a few scattered ones struck his cheek and glanced off. A hard metallic smile spread over his countenance, as he leaned his shoulders against the door frame, and again commenced: "My dear madam, such spasmodic manifestations of your disinclination to make a judicious investment of a few paltry dollars—"

"Hi—eo!" shrieked the widow, and collapsed into a kind of jerking swoon, and before she had recovered a highly magnetic lightning rod decorated her humble domicile, and Parsons had the blank note filled out already for her signature.—*Madison (Ind.) Courier.*

To Correspondents.

*** Duly authenticated contributions, theoretical and practical, on every subject identified with the interests of which "The Telegraphic Journal" is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the Editor; business communications to the Publishers, 10, Paternoster Row, E.C.